# Apprenticeship and Industry Training

## Machinist

## Apprenticeship Course Outline

**1505.1 (2005)**

Government of Alberta ■

Apprenticeship and Industry Training

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# Machinist
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### Course Outline


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## Apprenticeship

Apprenticeship is post-secondary education with a difference. Apprenticeship begins with finding an employer. Employers hire apprentices, pay their wages and provide on-the-job training and work experience. Approximately 80 per cent of an apprentice's time is spent on the job under the supervision of a certified journeyperson or qualified tradesperson. The other 20 per cent involves technical training provided at, or through, a post-secondary institution – usually a college or technical institute.

To become certified journeypersons, apprentices must learn theory and skills, and they must pass examinations. Requirements for certification—including the content and delivery of technical training—are developed and updated by the Alberta Apprenticeship and Industry Training Board on the recommendation of Machinist Provincial Apprenticeship Committee.

The graduate of the Machinist apprenticeship program is a certified journeyperson who will be able to:

- have a thorough knowledge and understanding of the hand tools and power operated machines used for the shaping of metal into usable parts
- be skilful in the safe use of these tools in order to produce machine parts according to specifications
- be capable of reading and laying out projects from drawings
- skilfully use measuring devices to reproduce machine parts according to specifications
- know the characteristics of various metals
- understand the effects of heat treatment on metals and be skilful in the performance of the various heat treatment processes
- be familiar with the work in related trades such as mechanics, millwrights and welders
- produce work economically and meet the requirements of a competitive industry
- perform assigned tasks in accordance with quality and production standards required by industry

## Apprentice. 'ip and Industry Training System

### Industry-Driven

Alberta's apprenticeship and industry training system is an industry-driven system that ensures a highly skilled, internationally competitive workforce in more than 50 designated trades and occupations. This workforce supports the economic progress of Alberta and its competitive role in the global market. Industry (employers and employees) establishes training and certification standards and provides direction to the system through an industry committee network and the Alberta Apprenticeship and Industry Training Board. The Alberta government provides the legislative framework and administrative support for the apprenticeship and industry training system.

### Alberta Apprenticeship and Industry Training Board

The Alberta Apprenticeship and Industry Training Board provides a leadership role in developing Alberta's highly skilled and trained workforce. The board's primary responsibility is to establish the standards and requirements for training and certification in programs under the Apprenticeship and Industry Training Act. The board also provides advice to the Minister of Advanced Education and Technology on the needs of Alberta's labour market for skilled and trained workers, and the designation of trades and occupations.

The thirteen-member board consists of a chair, eight members representing trades and four members representing other industries. There are equal numbers of employer and employee representatives.

### Industry Committee Network

Alberta's apprenticeship and industry training system relies on a network of industry committees, including local and provincial apprenticeship committees in the designated trades, and occupational committees in the designated occupations. The network also includes other committees such as provisional committees that are established before the designation of a new trade or occupation comes into effect. All trade committees are composed of equal numbers of employer and employee representatives. The industry committee network is the foundation of Alberta's apprenticeship and industry training system.

**Local Apprenticeship Committees (LAC)**

Wherever there is activity in a trade, the board can set up a local apprenticeship committee. The board appoints equal numbers of employee and employer representatives for terms of up to three years. The committee appoints a member as presiding officer. Local apprenticeship committees:

- monitor apprenticeship programs and the progress of apprentices in their trade, at the local level
- make recommendations to their trade's provincial apprenticeship committee (PAC) about apprenticeship and certification in their trade
- promote apprenticeship programs and training and the pursuit of careers in their trade
- make recommendations to the board about the appointment of members to their trade's PAC
- help settle certain kinds of disagreements between apprentices and their employers
- carry out functions assigned by their trade's PAC or the board

**Provincial Apprenticeship Committees (PAC)**

The board establishes a provincial apprenticeship committee for each trade. It appoints an equal number of employer and employee representatives, and, on the PAC's recommendation, a presiding officer - each for a maximum of two terms of up to three years. Most PACs have nine members but can have as many as twenty-one. Provincial apprenticeship committees:

- make recommendations to the board about:
    - standards and requirements for training and certification in their trade
    - courses and examinations in their trade
    - apprenticeship and certification
    - designation of trades and occupations
    - regulations and orders under the Apprenticeship and Industry Training Act
- monitor the activities of local apprenticeship committees in their trade
- determine whether training of various kinds is equivalent to training provided in an apprenticeship program in their trade
- promote apprenticeship programs and training and the pursuit of careers in their trade
- consult with other committees under the Apprenticeship and Industry Training Act about apprenticeship programs, training and certification and facilitate cooperation between different trades and occupations
- consult with organizations, associations and people who have an interest in their trade and with employers and employees in their trade
- may participate in resolving certain disagreements between employers and employees
- carry out functions assigned by the board

**Machinist PAC Members at the time of publication**

| | | |
|---|---|---|
| Mr. G. Peterson | Edmonton | Presiding Officer |
| Mr. G. Lee | Calgary | Employer |
| Mr. L. Larsson | Edmonton | Employer |
| Mr. B. Wermann | Edmonton | Employer |
| Mr. R. Sond | Calgary | Employer |
| Mr. J. McGee | Lloydminster | Employee |
| Mr. D. Stetz | Calgary | Employee |
| Mr. L. Penner | Calgary | Employee |
| Mr. A. Thomson | Lethbridge | Employee |

**Alberta Government**

Alberta Advanced Education and Technology works with industry, employer and employee organizations and technical training providers to:

- facilitate industry's development and maintenance of training and certification standards
- provide registration and counselling services to apprentices and employers
- coordinate technical training in collaboration with training providers
- certify apprentices and others who meet industry standards

**Technical Institutes and Colleges**

The technical institutes and colleges are key participants in Alberta's apprenticeship and industry training system. They work with the board, industry committees and Alberta Advanced Education and Technology to enhance access and responsiveness to industry needs through the delivery of the technical training component of apprenticeship programs. They develop lesson plans from the course outlines established by industry and provide technical training to apprentices.

## Apprenticeship Safety

Safe working procedures and conditions, incident/injury prevention, and the preservation of health are of primary importance in apprenticeship programs in Alberta. These responsibilities are shared and require the joint efforts of government, employers, employees, apprentices and the public. Therefore, it is imperative that all parties are aware of circumstances that may lead to injury or harm.

Safe learning experiences and healthy environments can be created by controlling the variables and behaviours that may contribute to or cause an incident or injury. By practicing a safe and healthy attitude, everyone can enjoy the benefit of an incident and injury free environment.

**Alberta Apprenticeship and Industry Training Board Safety Policy**

The Alberta Apprenticeship and Industry Training Board fully supports safe learning and working environments and encourages the teaching of proper safety procedures both within trade specific training and in the workplace.

Trade specific safety training is an integral component of technical training, while ongoing or general non-trade specific safety training remains the responsibility of the employer and the employee as required under workplace health and safety legislation.

**Workplace Responsibilities**

The employer is responsible for:

- training employees and apprentices in the safe use and operation of equipment
- providing and maintaining safety equipment, protective devices and clothing
- enforcing safe working procedures
- providing safeguards for machinery, equipment and tools
- observing all accident prevention regulations

The employee and apprentice are responsible for:

- working in accordance with the safety regulations pertaining to the job environment
- working in such a way as not to endanger themselves, fellow employees or apprentices

**Workplace Health and Safety**

A tradesperson is often exposed to more hazards than any other person in the work force and therefore should be familiar with and apply the Occupational Health and Safety Act, Regulations and Code when dealing with personal safety and the special safety rules that apply to all daily tasks.

Workplace Health and Safety (Alberta Employment, Immigration and Industry) conducts periodic inspections of workplaces to ensure that safety regulations for industry are being observed.

Additional information is available at www.worksafely.org

## Technical Training

Apprenticeship technical training is delivered by the technical institutes and many colleges in the public post-secondary system throughout Alberta. The colleges and institutes are committed to delivering the technical training component of Alberta apprenticeship programs in a safe, efficient and effective manner. All training providers place great emphasis on safe technical practices that complement safe workplace practices and help to develop a skilled, safe workforce.

The following institutions deliver Machinist apprenticeship technical training:

Northern Alberta Institute of Technology

Southern Alberta Institute of Technology

## Procedures for Recommending Revisions to the Course Outline

Advanced Education and Technology has prepared this course outline in partnership with the Machinist Provincial Apprenticeship Committee.

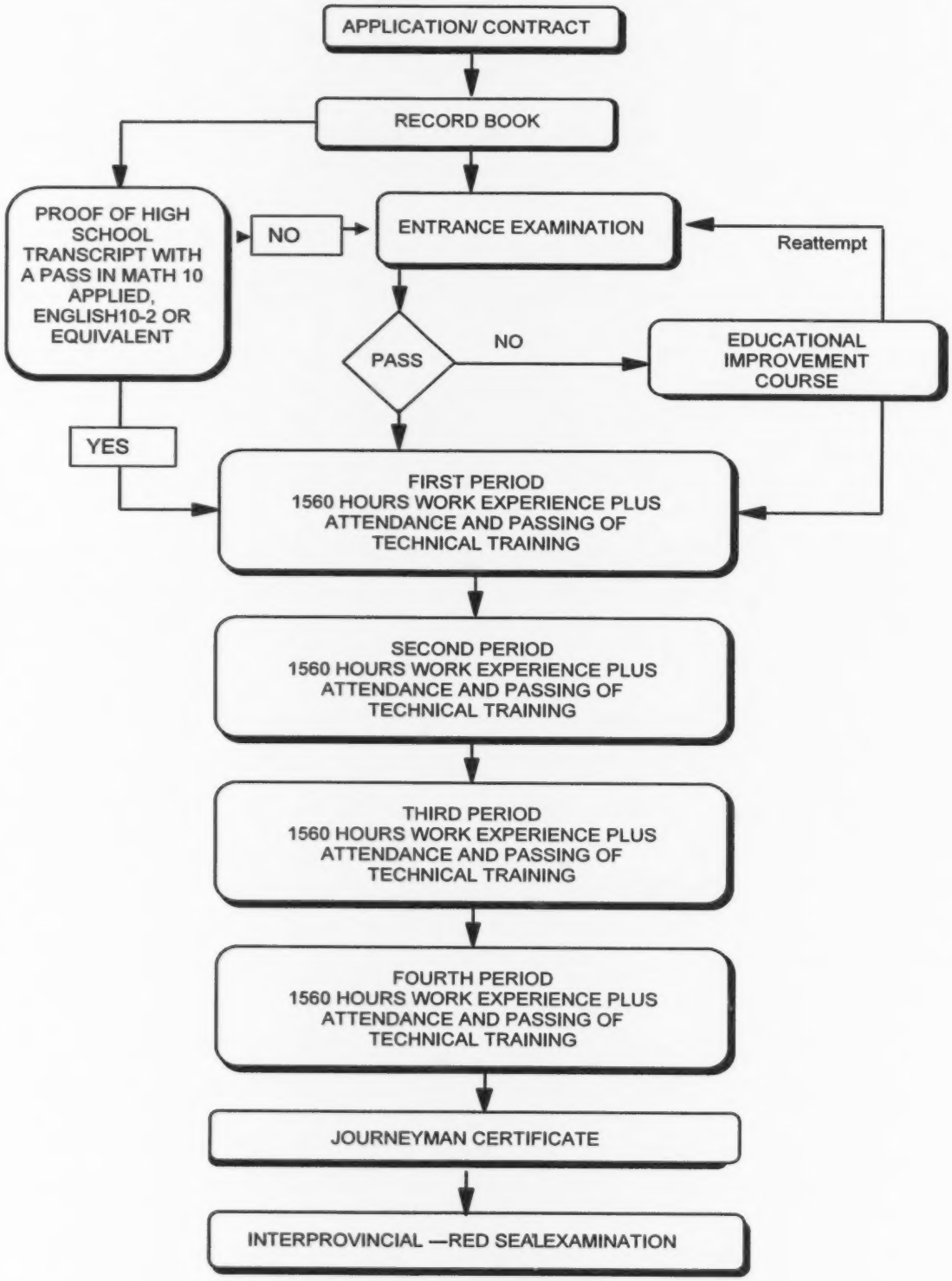
This course outline was approved on September 30, 2005 by the Alberta Apprenticeship and Industry Training Board on a recommendation from the Provincial Apprenticeship Committee. The valuable input provided by representatives of industry and the institutions that provide the technical training is acknowledged.

Any concerned individual or group in the province of Alberta may make recommendations for change by writing to:

Machinist Provincial Apprenticeship Committee
c/o Industry Programs and Standards
Apprenticeship and Industry Training
Advanced Education and Technology
10th floor, Commerce Place
10155 102 Street NW
Edmonton AB T5J 4L5

It is requested that recommendations for change refer to specific areas and state references used. Recommendations for change will be placed on the agenda for regular meetings of the Machinist Provincial Apprenticeship Committee.

**Apprenticeship Route toward Certification**


APPLICATION/ CONTRACT
RECORD BOOK
PROOF OF HIGH SCHOOL TRANSCRIPT WITH A PASS IN MATH 10 APPLIED, ENGLISH10-2 OR EQUIVALENT
NO
ENTRANCE EXAMINATION
Reattempt
PASS
NO
EDUCATIONAL IMPROVEMENT COURSE
YES
FIRST PERIOD
1560 HOURS WORK EXPERIENCE PLUS ATTENDANCE AND PASSING OF TECHNICAL TRAINING
SECOND PERIOD
1560 HOURS WORK EXPERIENCE PLUS ATTENDANCE AND PASSING OF TECHNICAL TRAINING
THIRD PERIOD
1560 HOURS WORK EXPERIENCE PLUS ATTENDANCE AND PASSING OF TECHNICAL TRAINING
FOURTH PERIOD
1560 HOURS WORK EXPERIENCE PLUS ATTENDANCE AND PASSING OF TECHNICAL TRAINING
JOURNEYMAN CERTIFICATE
INTERPROVINCIAL —RED SEALEXAMINATION

## Machinist Training Profile
## FIRST PERIOD
## (8 Weeks 30 Hours per Week – Total of 240 Hours)

**SECTION ONE**

**THEORY** — **72 HOURS**

| A | B | C |
|---|---|---|
| WHMIS<br>150101a — 2 Hours | Basic Measuring Tools<br>150101b — 2 Hours | Precision Measuring Tools<br>150101c — 2 Hours |
| **D** | **E** | **F** |
| Angular Measuring Tools<br>150101d — 2 Hours | Inspection Gauges<br>150101e — 2 Hours | Layout Tools and Procedures<br>150101f — 2 Hours |
| **G** | **H** | **I** |
| Non-Cutting Hand Tools<br>151010g — 4 Hours | Hand-Held Cutting Tools<br>150101h — 6 Hours | Screw Thread Terminology<br>150101i — 5 Hours |
| **J** | **K** | **L** |
| Screw Thread Measuring and Gauging<br>150101j — 3 Hours | Fasteners and Locking Devices<br>150101k — 3 Hours | Tapers<br>150101l — 5 Hours |
| **M** | **N** | **O** |
| Machine Lubrication and Cutting Fluids<br>150101m — 2 Hours | Hand Grinding Machines<br>150101n — 2 Hours | Drilling Machines<br>150101o — 8 Hours |
| **P** | **Q** | **R** |
| Types of Lathes<br>150101p — 6 Hours | Speeds, Feeds and Cutting Tools<br>150101q — 4 Hours | Lathe Operations<br>150101r — 8 Hours |
| **S** | **T** | |
| Power Saws and Cut-off Machines<br>150101s — 2 Hours | Machine Shop Rigging<br>150101t — 2 Hours | |

**SECTION TWO**

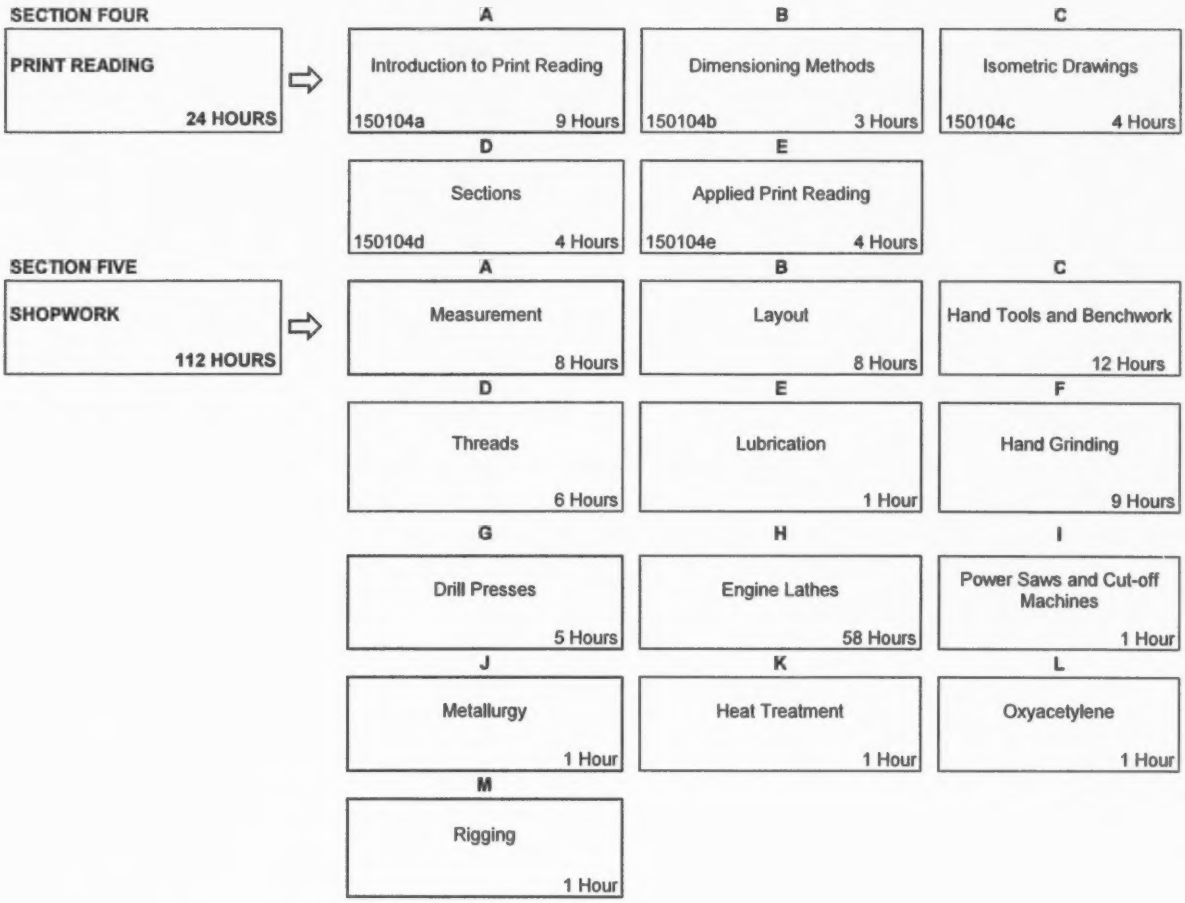
**METALLURGY AND HEAT TREATMENT** — **8 HOURS**

| A | B |
|---|---|
| Metallurgy<br>150102a — 4 Hours | Oxyacetylene Equipment<br>150102b — 4 Hours |

**SECTION THREE**

**TRADE MATHEMATICS** — **24 HOURS**

| A | B | C |
|---|---|---|
| Manipulation of Whole Numbers, Fractions, and Decimals.<br>3 Hours | Measurements and Conversions<br>2 Hours | Formulas and Equations<br>6 Hours |
| **D** | **E** | **F** |
| Reading Tables, Graphs and Nomographs<br>2 Hours | Ratio and Proportion<br>3 Hours | Percentage Calculations<br>3 Hours |
| **G** | | |
| Triangles<br>5 Hours | | |


SECTION FOUR
PRINT READING
24 HOURS
A
Introduction to Print Reading
150104a
9 Hours
B
Dimensioning Methods
150104b
3 Hours
C
Isometric Drawings
150104c
4 Hours
D
Sections
150104d
4 Hours
E
Applied Print Reading
150104e
4 Hours
SECTION FIVE
SHOPWORK
112 HOURS
A
Measurement
8 Hours
B
Layout
8 Hours
C
Hand Tools and Benchwork
12 Hours
D
Threads
6 Hours
E
Lubrication
1 Hour
F
Hand Grinding
9 Hours
G
Drill Presses
5 Hours
H
Engine Lathes
58 Hours
I
Power Saws and Cut-off Machines
1 Hour
J
Metallurgy
1 Hour
K
Heat Treatment
1 Hour
L
Oxyacetylene
1 Hour
M
Rigging
1 Hour

## SECOND PERIOD
## (8 Weeks 30 Hours per Week – Total of 240 Hours)

**SECTION ONE**

**THEORY** — **48 HOURS**

| A | B | C |
|---|---|---|
| Milling Machines<br>150201a — 4 Hours | Milling Cutters<br>150201b — 5 Hours | Tool and Work Holding Devices<br>150201c — 2 Hours |
| **D** | **E** | **F** |
| Milling Operations<br>150201d — 9 Hours | Dividing Head and Indexing<br>150201e — 4 Hours | Advanced Threading<br>150201f — 8 Hours |
| **G** | **H** | **I** |
| Lathe Attachments and Accessories<br>150201g — 4 Hours | Advanced Cutting Tool Materials<br>150201h — 4 Hours | Inserts and Tool Holders<br>150201i — 4 Hours |
| **J** | **K** | |
| Using Carbide Inserts<br>150201j — 2 Hours | Shapers and Slotters<br>150201k — 2 Hours | |

**SECTION TWO**

**COMPUTER NUMERICAL CONTROM MACHINES** — **12 HOURS**

| A | B | C |
|---|---|---|
| CNC Machines: Introduction and Applications<br>150202a — 2 Hours | CNC Turning Centers: Types, Parts and Workholding Accessories<br>150202b — 2 Hours | CNC Turning Centers: Program and Machine Coordination Systems<br>150202c — 2 Hours |
| **D** | **E** | **F** |
| CNC Turning Centers: Cutting Conditions and Operations<br>150202d — 2 Hours | CNC Turning Centers: Program Concepts and Codes<br>150202e — 2 Hours | CNC Turning Centers: Program Applications<br>150202f — 2 Hours |

**SECTION THREE**

**METALLURGY** — **16 HOURS**

| A | B |
|---|---|
| Base Metals and Alloys<br>150203a — 10 Hours | Metal Specification and Testing<br>150203b — 6 Hours |

**SECTION FOUR**

**TRADE MATHEMATICS** — **24 HOURS**

| A | B | C |
|---|---|---|
| Measurements, Conversions, Ratio and Proportion<br>6 Hours | Applied Mathematics<br>14 Hours | Applied Geometry<br>4 Hours |

**SECTION FIVE**

**BLUEPRINT READING** — **24 HOURS**

| A | B | C |
|---|---|---|
| Interpret and Sketch Blueprints<br>150205a — 8 Hours | Symbols and abbreviations<br>150205b — 8 Hours | Assembly and Sub-Assembly Drawings<br>150205c — 8 Hours |

**SECTION SIX**

**MACHINERY'S HANDBOOK** — **8 HOURS**

| A |
|---|
| Machinery's Handbook<br>150206a — 8 Hours |

**SECTION SEVEN**

**SHOPWORK** — **112 HOURS**

| A | B | C |
|---|---|---|
| Milling Machines — 54 Hours | Engine Lathes — 46 Hours | Lathe Attachments — 6 Hours |

| D |
|---|
| CNC Machining — 6 Hours |

## THIRD PERIOD
## (8 Weeks 30 Hours per Week – Total of 240 Hours)

**SECTION ONE**

**THEORY** — **50 HOURS**

| A | B | C |
|---|---|---|
| Advanced Milling — 150301a — 5 Hours | Worm Threads — 150301b — 4 Hours | Multiple Start Threads — 150301c — 2 Hours |
| **D** | **E** | **F** |
| Introduction to Gearing — 150301d — 6 Hours | Gear Manufacturing Methods — 150301e — 8 Hours | Abrasives — 150301f — 3 Hours |
| **G** | **H** | **I** |
| Grinding Machines and Processes — 150301g — 6 Hours | Boring Mills — 150301h — 4 Hours | Jig Boring and Grinding — 150301i — 2 Hours |
| **J** | **K** | **L** |
| Machine Broaching — 150301j — 1 Hour | Jigs and Fixtures — 150301k — 5 Hours | Estimating — 150301l — 4 Hours |

**SECTION TWO**

**COMPUTER NUMERICAL CONTROL MACHINES** — **25 HOURS**

| A | B | C |
|---|---|---|
| CNC Turning Centres: Program Codes and Format — 150302a — 4 Hours | Fixed Canned Cycles — 150302b — 1 Hour | Linear and Circular Interpolation — 150302c — 1 Hour |
| **D** | **E** | **F** |
| Multiple Repetitive Cycles — 150302d — 4 Hours | Tool Nose Radius Compensation — 150302e — 3 Hours | CNC Threading: Introduction and Calculations — 150302f — 3 Hours |
| **G** | **H** | **I** |
| CNC Threading: Programming and Troubleshooting — 150302g — 5 Hours | Tool Measurements — 150302h — 2 Hours | Machine Control and Operation — 150302i — 2 Hours |

**SECTION THREE**

**TRADE MATHEMATICS** — **24 HOURS**

| A | B | C |
|---|---|---|
| Applied Mathematics — 2 Hours | Introduction to Trigonometry — 8 Hours | Shop Applications of Trigonometry – Imperial and Metric — 12 Hours |

| D |
|---|
| CNC Maths — 2 Hours |

**SECTION FOUR**

**PRINT READING** — **16 HOURS**

| A | B | C |
|---|---|---|
| Interpret and Sketch Prints — 6 Hours | Print Reading: Casting — 4 Hours | Print Reading: Jigs and Fixtures — 6 Hours |

**SECTION FIVE**

**MACHINERY'S HANDBOOK** — **8 HOURS**

| A |
|---|
| Machinery's Handbook — 8 Hours |

**SECTION SIX**

**SHOPWORK** — **117 HOURS**

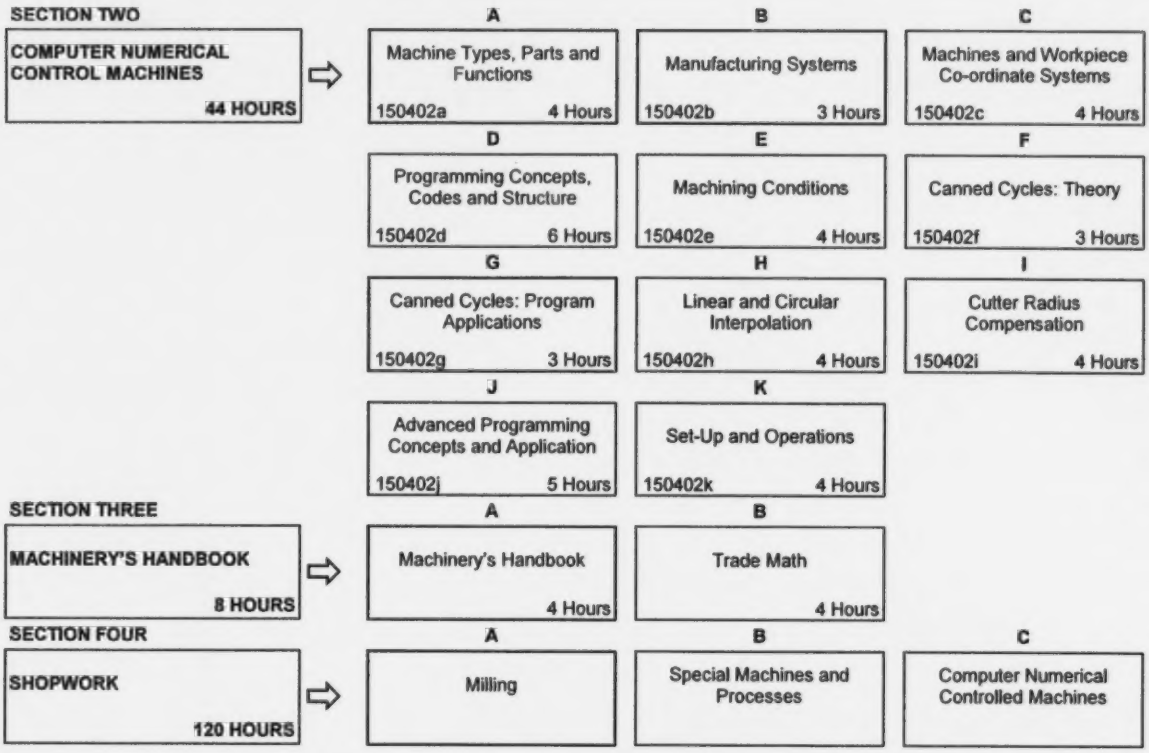
| A | B | C |
|---|---|---|
| Grinding | Milling | Lathe Work – Threading |
| **D** | **E** | **F** |
| Boring Mills | Machine Broaching | Jigs and Fixtures |
| **G** | | |
| Computer Numerical Control Machine | | |

## FOURTH PERIOD
## (8 Weeks 30 Hours per Week – Total of 240 Hours)

**SECTION ONE**

**THEORY** — **68 HOURS**

| A | B | C |
|---|---|---|
| Spur Gears and Milling — 150401a — 2 Hours | Helical Gears — 150401b — 4 Hours | Worm Gears — 150401c — 4 Hours |
| **D** | **E** | **F** |
| Bevel Gears — 150401d — 2 Hours | Cams — 150401e — 2 Hours | Graduating — 150401f — 2 Hours |
| **G** | **H** | **I** |
| Splines — 150401g — 4 Hours | Bearing and Seals — 150401h — 5 Hours | Belts and Pulleys — 150401i — 3 Hours |
| **J** | **K** | **L** |
| Basic Hydraulics — 150401j — 4Hours | Non-Traditional Manufacting Processes — 150401k — 12 Hours | Introduction to Limits and Fits — 150401l — 6 Hours |
| **M** | **N** | **O** |
| Surface Finish — 150401m — 6 Hours | Precision Measurement — 150401n — 6 Hours | Gauges and Comparators — 150401o — 2 Hours |
| **P** | **Q** | **R** |
| Calibration of Measuring Tools — 150401p — 4 Hours | Workplace Coaching Skills — 150401q — 0 Hours | Purpose of Advisory Network — 150401o — 0 Hours |




NOTE: The hours stated are for guidance and should be adhered to as closely as possible. However, adjustments must be made for rate of apprentice learning, statutory holidays, registration and examinations for the training establishment and Apprenticeship and Industry Training.

**FIRST PERIOD TECHNICAL TRAINING**
**MACHINIST TRADE**
**COURSE OUTLINE**

*UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.*

**SECTION ONE: ..... THEORY ..... 72 HOURS**

**A. WHMIS (150101a) ..... 2 Hours**

***Outcome:*** ***Apply the requirements of WHMIS to the worksite.***

1. Describe the three key elements of WHMIS.
2. Identify WHMIS safety hazard symbols.
3. Interpret the Material Safety Data Sheet (MSDS).

**B. Basic Measurement Tools (150101b) ..... 2 Hours**

***Outcome:*** ***Measure components using basic tools common to the trade.***

1. Identify basic measuring tools common to the trade.
2. Measure round and flat components to 1/64" or 0.5 mm accuracy.

**C. Precision Measuring Tools (150101c) ..... 2 Hours**

***Outcome:*** ***Measure workpieces using precision measuring tools common to the trade.***

1. Identify precision measuring tools used in the machine shop.
2. Perform precision measurement with both metric and imperial measuring tools.
3. Demonstrate correct care and use of measuring tools.

**D. Angular Measuring Tools (150101d) ..... 2 Hours**

***Outcome:*** ***Measure workpieces using angular measuring tools common to the trade.***

1. Measure angles using a bevel and plate protractor.
2. Measure to within 5 minutes of a degree of accuracy using a universal bevel protractor.
3. Describe dial indicators and gauge blocks for measurement and set-up operations.
4. Perform angular measurement using the sine bar method.
5. Identify three types of sine plate.
6. Identify, select and apply precision squares for checking squareness of workpeices and set-up purposes.

**E. Inspection Gauges (150101e) ..... 2 Hours**

***Outcome:*** ***Check components using various types of inspection gauges.***

1. Use fixed gauges to check the accuracy of components.
2. Define the terminology associated with limits and fits.
3. Explain the effects of temperature changes, with respect to measuring components, when applying limits and fits.

**F. Layout Tools and Procedures (150101f) ..... 2 Hours**

***Outcome:*** ***Perform semi-precision and precision layout procedures.***

1. Identify the tools for layout procedures.
2. Explain the procedures for basic (semi-precision) and precision layout.

**G. Non-Cutting Hand Tools (150101g) ..... 4 Hours**

***Outcome:*** ***Demonstrate the correct use of non-cutting hand tools common to the trade.***

1. Select the appropriate hand tool to hold, assemble or disassemble components.
2. Describe the proper technique to hold, assemble or disassemble components.
3. Describe the use of metal stamps for marking components.

**H. Hand-Held Cutting Tools (150101h) ..... 6 Hours**

***Outcome:*** ***Demonstrate the correct use of hand-held cutting tools common to the trade.***

1. Describe hacksaws, hacksaw blades, and hole saws.
2. Describe the parts, types, classification, shape and use of files.
3. Describe the use of scrappers and chisels.
4. Describe the use of taps and dies, stud and bolt removal tools, and the proper lubricant for these applications.
5. Describe hand reamers and their applications.
6. Describe the use of hand-held cutting pliers, hand broaching tools and abrasives.

**I. Screw Thread Terminology (150101i) ..... 5 Hours**

***Outcome:*** ***Interpret a thread designation.***

1. Define the term screw thread and list four screw thread applications.
2. Identify the parts of external and internal screw threads.
3. Identify eight screw thread forms and their applications.
4. Explain the terminology associated with thread classification and fits.

**J. Screw Thread Measuring and Gauging (150101j) ..... 3 Hours**

***Outcome:*** ***Inspect screw thread forms using five gauging and measuring methods.***

1. Perform thread calculations for four thread forms.
2. Describe the various methods used to accurately measure and gauge threads.

**K. Fasteners and Locking Devices (150101k) ..... 3 Hours**

***Outcome:*** ***Select a threaded or non-threaded mechanical fastener to meet job specifications.***

1. Identify types of threaded fasteners and their applications.
2. Identify types of non-threaded fasteners and their applications.

**L. Taper Systems (150101l) ..... 5 Hours**

***Outcome:*** ***Apply taper systems to machining operations.***

1. State four applications of tapers.
2. Identify the individual parts of a taper.
3. Describe the various methods used to measure or gauge an external or internal taper for fit and accuracy.
4. Identify eight taper systems and their applications.
5. Perform calculations for both metric and imperial tapers.

**M. Machine Lubrication and Cutting Fluids (150101m) ..... 2 Hours**

***Outcome:*** ***Apply lubricants to reduce friction and increase efficiency.***

1. Describe the purpose of lubrication.
2. Interpret lubrication schedules from manufacturer's specifications and apply the appropriate lubricant.
3. Identify the various methods used to apply lubricants.
4. Describe the characteristics and functions of a cutting fluid.
5. Describe the applications and potential health hazards of cutting fluids.

**N. Hand Grinding Machines (150101n) ..... 2 Hours**

***Outcome:*** ***Perform off-hand grinding on the bench or pedestal grinder.***

1. Identify three types of hand grinding machines and the types of wheels they use.
2. Describe the correct method to install, true and dress a grinding wheel.

**O. Drilling Machines (150101o) ..... 8 Hours**

***Outcome:*** ***Describe the procedures to operate drilling machines.***

1. Identify seven types of drilling machines, their main parts and attachments.
2. Describe the various types of drill press operations.
3. Describe tool and work holding devices.
4. Identify the parts of a twist drill and the types of twist drill materials.
5. Describe special types of drills and reamers.
6. Explain metric, fractional, letter and number drill sizes and methods of measuring drill sizes.
7. Describe the different procedures for grinding a drill bit and the techniques used to correct for drilling problems.
8. Calculate the correct speeds and feeds for drill press operations.

**P. Types of Lathes (150101p) ..... 6 Hours**

***Outcome:*** ***Describe the sizing, parts, accessories and attachments of lathe types.***

1. Identify the types, size, and related capacity of lathes found in industry.
2. Describe the five major parts of an engine lathe and their functions.
3. Explain the use of work holding devices when used on the lathe.
4. Describe lathe accessories and their applications.
5. Explain the use of tool posts and cutting tool holders.
6. Prevent potential hazards by following the safety procedures when operating lathe.

**Q. Speeds, Feeds and Cutting Tools (150101q) ..... 4 Hours**

***Outcome:*** ***Determine the feed, speed, and depth of cut for turning operations.***

1. Describe the composition and characteristics of six types of cutting tool materials.
2. Identify the shapes, angles and clearances, when grinding a cutting tool.
3. Calculate the speeds and feeds for various cutting tool and workpiece materials.
4. Determine the depth of cut and feed rate based on five determining factors.

**R. Lathe Operations (150101r) ..... 8 Hours**

***Outcome:*** ***Perform engine lathe set-ups and operations safely.***

1. Set-up the cutting tool to perform parallel turning and boring operations.
2. Operate a lathe to turn a shoulder.
3. Perform center drilling, drilling and reaming operations.
4. Set-up a lathe to cut tapers.
5. Perform knurling, grooving, parting-off, forming and profiling, in the lathe.
6. Use taps, dies, and a single point tool to cut a thread.
7. Describe the use of steady rests, follower rests, and mandrels on the lathe.
8. Follow safety guidelines when performing finishing operations in the lathe.

**S. Power Saws and Cut-off Machines (150101s) ..... 2 Hours**

***Outcome:*** ***Operate power saws and cut-off machines safely.***

1. Describe the types, design features, and applications of power saws and cut-off machines.
2. Demonstrate the correct procedures when using power saws and cut-off machines.
3. Select a saw blade or cut-off wheel.

**T. Machine Shop Rigging (150101t) ..... 2 Hours**

***Outcome:*** ***Comply with Occupational Health and Safety Regulations when hoisting machine components in the machine shop.***

1. Describe rigging hardware and the safety factor associated with each item.
2. Demonstrate hoisting procedures and methods of calculating sling tension and load weight.

**SECTION TWO: .....METALLURGY AND HEAT TREATMENT.....8 HOURS**

**A. Metallurgy (150102a).....4 Hours**

***Outcome:*** ***Select the correct type of metal for an application.***

1. Explain five physical and mechanical properties of steel and the factors that change these properties.
2. Describe steel processing and finishing methods and the shapes that may be produced by rolling.
3. Demonstrate the use of the SAE-AISI classification system to identify metals.
4. Describe heat-treating and the terminology associated with these processes.

**B. Oxyacetylene Equipment (150102b) .....4 Hours**

***Outcome:*** ***Use oxyacetylene equipment for heating, cutting and silver brazing.***

1. Use the appropriate safety precautions and devices.
2. Describe oxygen and acetylene cylinders and the nature and production of the gases.
3. Install oxyacetylene equipment safely.
4. Describe set-up, pressure and flame adjustment, and shutdown, when using oxyacetylene equipment.
5. Perform heating, cutting and silver brazing operations.

**SECTION THREE: .....TRADE MATHEMATICS.....24 HOURS**

**A. Manipulation of Whole Numbers, Fractions and Decimals .....3 Hours**

***Outcome:*** ***Manipulate whole numbers, fractions and decimals.***

1. Solve problems involving addition and subtraction of whole numbers and decimals.
2. Solve problems involving multiplication and division of whole numbers and decimals.
3. Calculate the average of several numbers.
4. Factor fractions to lowest common denominator.
5. Calculate the lowest common multiple.
6. Add and subtract fractions.
7. Multiply and divide fractions.
8. Solve exponential problems involving whole numbers and fractions.
9. Convert fractions to decimals and vice versa.
10. Round off whole numbers, fractions and decimals.

**B. Measurements and Conversions.....2 Hours**

***Outcome:*** ***Calculate measurements and conversions using metric and imperial measurement systems.***

1. List the basic metric units of length, mass, volume, time and temperature with their symbols.
2. Define the prefixes used to indicate large and small quantities.
3. List the derived metric units and their symbols.
4. Convert imperial units to metric and vice versa using tables and calculators.
5. List the conversions and equivalents for Imperial measurement.

**C. Formulas and Equations .....6 Hours**

***Outcome:*** ***Manipulate formulas and equations.***

1. Recognize and be able to manipulate formulas according to the proper math rules.
2. Group formulas and equations according to their sequence of operations and be able to solve problems using these rules.
3. Solve various problems with the use of proper formula in both imperial and metric for area, volumes, perimeter and circumference.

**D. Reading Tables, Graphs and Nomographs .....2 Hours**

***Outcome:*** ***Read tables, graphs and nomographs.***

1. Read and interpret tables and graphs available to provide information to the machinist.
2. Solve problems using tables and graphs used in the machinist trade.

**E. Ratio and Proportion .....3 Hours**

***Outcome:*** ***Define and use ratio and proportion.***

1. Define ratio.
2. Define proportion.
3. Apply ratio and proportion formula in solving various shop problems involving gearing and pulleys.

**F. Percentage Calculations .....3 Hours**

***Outcome:*** ***Solve problems using percentages.***

1. Calculate percent for various mathematical expressions used in the machinist trade.
2. Change percentages of various mathematical expressions used in the machinist trade.

**G. Triangles .....5 Hours**

***Outcome:*** ***Identify and use triangles.***

1. Identify common triangles.
2. Identify parts of triangles.
3. Define and apply the Pythagorean theorem.
4. Define and apply the similar triangle method to determine the angles on a right angle triangle.
5. Identify and explain the application of triangles.

6. Demonstrate the use of ratio and proportion using triangles to solve shop problems.

**SECTION FOUR: .....PRINT READING.....24 HOURS**

**A. Introduction to Print Reading (150104a).....9 Hours**

***Outcome:*** ***Read and sketch basic components.***

1. Identify the six planes of an orthographic projection and the ~~-~~key view".
2. Identify first and third angle projections, and recognize the ISO symbol for each projection.
3. Describe the types of lines used on prints and their applications.
4. Describe basic sketching equipment.
5. Use basic rules to apply dimensions to a component drawing.
6. Sketch and dimension simple objects in orthographic projection.

**B. Dimensioning Methods (150104b).....3 Hours**

***Outcome:*** ***Dimension and interpret various common elements.***

1. Describe the different methods of applying special dimensions to a technical element on a print.
2. State the methods used to express the amount of taper on a component drawing.
3. Read dimensions on prints in both metric and imperial systems or dual dimensioning.

**C. Isometric Drawings (150104c) .....4 Hours**

***Outcome:*** ***Sketch pictorial drawings.***

1. Calculate for missing dimensions on a drawing.
2. Describe three types of picture views.
3. Sketch isometric drawings on isometric lined paper.

**D. Sections (150104d) .....4 Hours**

***Outcome:*** ***Recognize and name technical elements of break lines and sectional representation.***

1. Define the terms cutting plane lines, break lines and symmetry and describe their application.
2. Describe the use of sectional views and name the types of components that would not be sectioned on a drawing.
3. Draw symbolic section lines for seven types of material.

**E. Applied Print Reading (150104e).....4 Hours**

***Outcome:*** ***Sketch and interpret machine shop drawings containing applied print reading terminology.***

1. Calculate the limits and fits for the mating parts on working drawings.
2. Apply all dimensions and tolerances to a set of working drawings.
3. Interpret prints including all information generally provided on prints, shop drawings and sketches.

**SECTION FIVE:..... SHOPWORK..... 112 HOURS**

Shopwork experience will relate items outlined in the theory section to shop operations by producing selected shop projects. This experience should compliment the theory instruction by providing opportunities for efficient, productive and safe operation and/or demonstrations thereof.

**A. Measurement.....8 Hours**

***Outcome:*** ***Use various measurement devices.***

1. Demonstrate an ability to measure and fit with the use of various measurement devices.

**B. Layout.....8 Hours**

***Outcome:*** ***Perform layout using appropriate tools.***

1. Perform layout procedures using various layout tools.

**C. Hand Tools and Benchwork.....12 Hours**

***Outcome:*** ***Develop ability to use hand tools.***

1. Demonstrate an ability to perform operations with the use of various hand tools.

**D. Threads.....6 Hours**

***Outcome:*** ***Demonstrate thread cutting and related operations.***

1. Perform various thread cutting and related operations using the proper tools.
2. Perform various thread repair operations.

**E. Lubrication.....1 Hour**

***Outcome:*** ***Perform lubrications on various machine tools.***

1. Perform proper lubrication requirements on various machine tools using the required lubricants.
2. Use manufacturer's lubrication charts for proper lubrication.

**F. Hand Grinding.....9 Hours**

***Outcome:*** ***Demonstrate the use and maintenance of offhand and bench grinders.***

1. Demonstrate an ability to use offhand and bench grinders for grinding and sharpening.
2. Demonstrate and perform maintenance operations on grinders.

**G. Drill Presses.....5 Hours**

***Outcome:*** ***Perform various drilling operations.***

1. Perform drilling operations using various drilling machines and attachments.
2. Demonstrate an ability to safely and efficiently perform various functions on the appropriate drilling machines.

**H. Engine Lathes ..... 58 Hours**

***Outcome:*** ***Demonstrate various lathe operations and set-ups.***

1. Safely and efficiently perform various set ups for different operations on the engine lathe.
2. Demonstrate an ability to perform various operations on the lathe.

**I. Power Saws and Cut-Off Machines ..... 1 Hour**

***Outcome:*** ***Demonstrate various operations using power saws and cut-off machines.***

1. Perform stock cutting operations on power saws.
2. Perform sawing operations on the contour bandsaw.
3. Demonstrate various functions related to bandsaws.
4. Perform stock cutting operations on the abrasive cut-off machine.

**J. Metallurgy ..... 1 Hour**

***Outcome:*** ***Demonstrate heat treatment on small hand tools using oxyacetylene equipment.***

1. Demonstrate the safe use of oxyacetylene equipment.
2. Demonstrate oxyacetylene equipment to heat treat small hand tools.

**K. Heat Treatment ..... 1 Hour**

***Outcome:*** ***Perform heat treatment operations.***

1. Demonstrate an ability to perform heat treatment operations.

**L. Oxyacetylene ..... 1 Hour**

***Outcome:*** ***Perform heating, brazing and cutting operations using oxyacetylene equipment.***

1. Demonstrate an ability to perform operations using oxyacetylene equipment.

**M. Rigging ..... 1 Hour**

***Outcome:*** ***Perform basic rigging operations.***

1. Demonstrate the use of hand signals.
2. Demonstrate and perform hoisting operations as they pertain to rigging and hardware.

**SECOND PERIOD TECHNICAL TRAINING**
**MACHINIST TRADE**
**COURSE OUTLINE**

*UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.*

**SECTION ONE:.....THEORY.....48 HOURS**

**A. Milling Machines (150201a).....4 Hours**

***Outcome:*** ***Describe milling machine types, parts and attachments.***

1. Describe the classification system for milling machine types.
2. Describe the use of the parts and controls on a knee and column, milling machine.
3. Describe the safe set-up and operation of milling machine attachments.

**B. Milling Cutters (150201b).....5 Hours**

***Outcome:*** ***Select the correct type of milling cutter and speed and feed for a machining application.***

1. Describe the types of materials used in the construction of milling cutters, and their applications and limitations.
2. Describe the arbour driven types of cutters used for operations on the horizontal milling machine.
3. Describe the types of cutters used for vertical milling machine operations.
4. Describe the care and handling of milling cutters.
5. Calculate the cutting speed, feed and depth of cut for various cutting tool and workpiece materials.

**C. Tool and Work Holding Devices (150201c).....2 Hours**

***Outcome:*** ***Select the proper tool and work holding device for a milling operation.***

1. Describe tool holding devices and their applications for the milling machine.
2. Describe work holding devices and their applications for the milling machine.

**D. Milling Operations (150201d).....9 Hours**

***Outcome:*** ***Describe the set-up and operation of a milling machine, using safe working procedures.***

1. Explain the difference between conventional and climb milling, and list the advantages of each.
2. Explain the difference between plain milling and face milling, and list the advantages of each.
3. Describe the set-up for cutting slots, keyways and keyseats.
4. Describe the set-up for using a slitting saw.
5. Describe the set-up for drilling and boring on a milling machine.
6. Describe the set-up for straddle, gang and from milling.
7. Describe the set-up for milling T-slots and dovetails.
8. Describe the set-up for hobbing a gear on a milling machine.

9. Describe safe procedures for operating a milling machine.

**E. Dividing Head and Indexing (150201e) ..... 4 Hours**

***Outcome:*** ***Describe four methods of indexing using a dividing head.***

1. Describe the applications of a dividing head, and each individual part.
2. Describe four methods of indexing.
3. Describe the use of a wide-range dividing head.
4. Describe the use of a rotary table.

**F. Advanced Threading (150201f) ..... 8 Hours**

***Outcome:*** ***Describe the types and uses of multiple start threads, translational threads, and taper threads.***

1. Describe the purpose of multiple start threads.
2. Describe the types and uses of translational threads.
3. Describe taper threads and their uses.

**G. Lathe Attachments and Accessories (150201g) ..... 4 Hours**

***Outcome:*** ***Perform lathe operations using lathe attachments and accessories.***

1. Describe the set-up and safe application of attachments used on the engine lathe.
2. Describe the set-up and safe application of accessories used on the engine lathe.

**H. Advanced Cutting Tool Materials (150201h) ..... 4 Hours**

***Outcome:*** ***Describe the mechanics of chip formation, the characteristics of high-speed steel, cast alloy, and carbide cutting tool materials, their methods of manufacture and their applications.***

1. Describe the mechanics of chip formation.
2. Identify and describe cutting tool material compositions, applications, and manufacture.
3. Describe the machining operations that use carbide tooling.

**I. Inserts and Tool Holders (150201i) ..... 4 Hours**

***Outcome:*** ***Choose and identify carbide inserts and tool holders.***

1. Interpret cutting tool geometry and its purpose.
2. Select an insert to provide the best operating conditions and economic performance for the job.
3. Interpret the ANSI and SI systems for the identification of carbide inserts and tool holders.

**J. Using Carbide Inserts (150201j) ..... 2 Hours**

***Outcome:*** ***Select the correct cutting conditions for an insert and identify and correct any problems that might arise.***

1. State the required operating conditions for carbide tools.
2. Describe carbide tool failure and the troubleshooting methods to safely correct the problem.

**K. Shapers and Slotters (150201k) ..... 2 Hours**

***Outcome:*** ***Describe various types of shapers, slotters, their parts, operations and applications.***

1. Identify the crank and hydraulic shapers.
2. Describe the difference between a shaper and a slotter.
3. List safety precautions regarding shapers and slotters.

**SECTION TWO: ..... COMPUTER NUMERICAL CONTROL MACHINES ..... 12 HOURS**

**A. CNC Machines: Introduction and Application (150202a) ..... 2 Hours**

***Outcome:*** ***Identify and explain basic CNC concepts, types of application of CNC machines, advantages, disadvantages and safety issues.***

1. Define basic terms used in CNC programming and machining.
2. Identify and describe the types of and applications for CNC machines.
3. State and discuss the advantages and disadvantages of CNC machines.
4. Identify and discuss safety practices when using CNC machines.

**B. CNC Turning Centers: Machine Types, Parts and Workholding Accessories (150202b). ..... 2 Hours**

***Outcome:*** ***Identify and explain basic CNC concepts and applications, parts and features of CNC turning centers.***

1. Types of CNC lathes and turning centers.
2. Identify and describe the parts, functions and features of CNC turning centers.
3. Identify the elements of a CNC drive system.
4. Identify and describe workholding devices and accessories used on CNC turning centers.

**C. CNC Turning Centers: Program and Machine Coordinate Systems (150202c) ..... 2 Hours**

***Outcome:*** ***Identify, determine and explain the purpose of co-ordinate and reference points used for CNC lathe programs.***

1. Determine co-ordinate points of a workpiece for both radius and diameter programming using absolute and incremental values.
2. Identify and explain the purpose of the CNC lathe axis system.
3. Identify and state a purpose for reference points used on CNC turning centers.

**D. CNC Turning Centers: Cutting Conditions and Operations (150202d) ..... 2 Hours**

***Outcome:*** ***Identify, select and apply speeds, feeds and depths of cut for turning operations. Identify the types and purposes of common turning operations.***

1. Determine and apply cutting conditions (speeds, feeds and depths of cuts) for basic lathe operations.
2. Identify and state the purpose of basic turning operations.

**E. CNC Turning Centers: Programming Concepts and Codes (150202e) ..... 2 Hours**

***Outcome:*** ***Identify and explain basic word address programming concepts and codes.***

1. Identify and explain elements of a word address program for a CNC turning center.
2. Identify and explain the purpose and application of preparatory (G) codes.
3. Identify and explain the purpose and application of miscellaneous (M) codes.
4. Identify, explain and apply tool, feed rate, speed and related program commands.
5. Identify, explain and apply tool and workpiece co-ordinates, and related program codes.

**F. CNC Turning Centers: Program Application (150202f) ..... 2 Hours**

***Outcome:*** ***Prepare and verify a word address program for CNC turning operations that include facing, cylindrical turning, center drilling and drilling operations.***

1. Identify and apply canned cycles for turning operations.
2. Write a CNC lathe program including the operations of facing, center drilling, drilling and cylindrical turning.
3. Explain methods of inputting, sorting and verifying CNC programs.

**SECTION THREE: ..... METALLURGY ..... 16 HOURS**

**A. Base Metals and Alloys (150203a) ..... 10 Hours**

***Outcome:*** ***Select the type of metal or alloy for the required operation.***

1. Describe the physical and mechanical properties of metals.
2. Describe the applications and mechanical properties of alloying elements used in steel.
3. Describe the characteristics of seven types of ferrous metals or alloys for machining operations.
4. Describe the characteristics of nine types of non-ferrous metals or alloys for machining operations.

**B. Metal Specifications and Testing (150203b) ..... 6 Hours**

***Outcome:*** ***Use metal specifications to select the correct metal for an application.***

1. Interpret charts and tables to select a metal for an application.
2. Describe six methods of destructive testing of metals.
3. Describe four methods of non-destructive testing of metals.

**SECTION FOUR: ..... TRADE MATHEMATICS ..... 24 HOURS**

The mathematics content in this course outline should maintain relevancy to technical training and be directly related to practical job applications.

**A. Measurements, Conversions, Ratio and Proportion ..... 6 Hours**

***Outcome:*** ***Use measurement, conversion, ratio and proportion to solve problems.***

1. Describe and identify imperial and metric systems of measurement and their applicable units.
2. Demonstrate an ability to solve various problems with the use of proper formulae in both imperial and metric.

3. Be able to demonstrate an ability to convert imperial measurements to metric and vice versa using appropriate formula.
4. Demonstrate an ability to solve various problems with the use of proper formula in both imperial and metric for area, volumes, perimeter and circumference.
5. Demonstrate an ability to compute various problems applying ratio and proportion formula relating to gearing and pulleys.

**B. Applied Mathematics ..... 14 Hours**

***Outcome:*** ***Demonstrate the ability to apply mathematics using various calculations, tables and charts.***

1. Demonstrate an ability to perform calculations on practical applications involving triangle theory and methods.
2. Demonstrate an ability to perform calculations on practical applications involving ratio and proportion formula.
3. Demonstrate an ability to read and interpret tables and charts.

**C. Applied Geometry ..... 4 Hours**

***Outcome:*** ***Demonstrate the ability apply geometry in calculation and problem solving.***

1. Identify and describe common geometric forms and terminology.
2. Be able to calculate the area of a triangle in both imperial and metric using the base altitude method and the three side method.
3. Be able to make various calculations on circles in both imperial and metric using proper formula and equations.
4. Be able to calculate the area of an ellipse and a trapezoid in both imperial and metric using proper formulae and equations.
5. Be able to calculate volume and weight (mass) in both imperial and metric using proper formula and equations.
6. Demonstrate an ability to calculate area and volumes in both metric and imperial using similar-figure method.

**SECTION FIVE: ..... PRINT READING ..... 24 HOURS**

**A. Interpret and Sketch Prints (150205a) ..... 8 Hours**

***Outcome:*** ***Interpret and sketch prints containing advanced technical information.***

1. Identify accumulation of tolerances.
2. Apply dimensions to tapers on sketching exercises.
3. Sketch and dimension technical element such as threads, boxes and countersinks.
4. Sketch and interpret a component in orthographic projection having a auxiliary view.
5. Sketch a pictorial drawing in isometric projection showing inclined surfaces, tapers and other technical elements.

**B. Symbols and Abbreviations (150205b) ..... 8 Hours**

***Outcome:*** ***Interpret various advanced symbols and abbreviations that are commonly seen on prints.***

1. Apply machining allowance symbols to component drawings to meet industry standards.
2. Describe the application and definitions associated with surface finish texture symbols.
3. Describe the specification associated with surface finish texture symbols.
4. Describe the purpose of a welding symbol.
5. Interpret the elements of a welding symbol.
6. Interpret elementary weld symbols for fillet welds.
7. Interpret elementary weld symbols for groove welds.
8. Identify basic weld symbols for plug, spot, and seam welds.
9. Identify basic structural steel shapes.
10. Interpret blueprints containing welding, machining and or structural steel shapes.

**C. Assembly and Sub-Assembly Drawings (150205c) ..... 8 Hours**

***Outcome:*** ***Sketch and interpret sub-assembly and assembly drawings. Define the purpose of assembly drawings.***

1. Sketch the layout and features typical of sub-assembly drawings.
2. Sketch the layout and features typical of assembly drawings.
3. Interpret part identification methods and bills of material on assembly drawings.
4. Interpret information found on assembly drawings and sub-assembly drawings.

**SECTION SIX:.....MACHINERY'S HANDBOOK..... 8 HOURS**

**A. Machinery's Handbook (150206a)..... 8 Hours**

***Outcome:*** ***Use the Machinery's Handbook to locate and interpret various tables, charts, graphs, text and other relevant information applicable to machine shop operations.***

1. Describe the Machinery's Handbook and explain its advantages.
2. Explain how to find information in the Machinery's Handbook.
3. Explain how to interpret tables, charts and other information found in the Machinery's Handbook.
4. Describe the contents of the Machinery's Handbook as applicable to the second year curriculum.

**SECTION SEVEN: .....SHOPWORK..... 108 HOURS**

Shopwork experience should relate items outlined in the theory section to shop operations by producing selected shop projects. This experience should complement the theory instruction by providing opportunities for efficient productive and safe operation and/or demonstration of:

**A. Milling Machines .....54 Hours**

***Outcome:*** ***Set up and operate various types of milling machines and their attachments.***

1. Demonstrate an ability to perform set-ups and operations on milling machines.
2. Demonstrate an ability to perform set-ups and operations on milling machine tooling.
3. Demonstrate an ability to use various tool holding devices for milling machines and their operations.
4. Perform speed and feed selections and settings for various milling operations.
5. Perform maintenance and lubrication requirements for milling machines.
6. Demonstrate an ability to use milling machine attachments in various milling operations.

**B. Engine Lathes .....46 Hours**

***Outcome:*** ***Demonstrate an ability to cut screw threads with single point tools on the engine lathe.***

1. Demonstrate an ability to cut screw thread forms with single point tools on the engine lathe.

**C. Lathe Attachments .....6 Hours**

***Outcome:*** ***Demonstrate the use of lathe attachments and their various tooling.***

1. Demonstrate an ability to use attachments and accessories for engine lathes.
2. Demonstrate an ability to select and use carbide and oxide tooling.

**D. CNC Machining .....6 Hours**

***Outcome:*** ***Perform CNC machining as outlined in the theory section.***

1. Demonstration on a CNC lathe to reinforce related items outlined in the theory section.

**THIRD PERIOD TECHNICAL TRAINING**
**MACHINIST TRADE**
**COURSE OUTLINE**

*UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.*

**SECTION ONE:.....THEORY ..... 56 HOURS**

**A. Advanced Milling (150301a).....5 Hours**

***Outcome:*** ***Perform advanced milling calculations and operations.***

1. Describe six applications of helical milling.
2. Calculate the lead, helix angle and gearing for a helical milling operation.
3. Set up a universal horizontal or vertical milling machine for helical milling.
4. Set up a milling machine for short-lead helical milling.

**B. Worm Threads (150301b).....4 Hours**

***Outcome:*** ***Perform calculations and set-up procedures to produce worm threads.***

1. Describe the purpose of the basic elements of plain, single enveloping, and double enveloping worm threads.
2. Calculate the size of the basic elements of a worm thread.
3. Describe the methods and materials used in the manufacture of worm threads.

**C. Multiple Start Threads (150301c) .....2 Hours**

***Outcome:*** ***Perform calculations and set-up procedures to produce multiple start threads.***

1. Describe the characteristics and applications of multiple start threads.
2. Describe the set-up procedures to cut a multiple start thread using single point cutting tools.

**D. Introduction to Gearing (150301d).....6 Hours**

***Outcome:*** ***Describe the basic theory of gear operation and application.***

1. Describe common types of gears and their applications.
2. Identify the terminology associated with each part of a spur gear.
3. Describe the purpose of four standard gear tooth forms.
4. Calculate the speed and gear ratios for simple and compound gears.

**E. Gear Manufacturing Methods (150301e) .....8 Hours**

***Outcome:*** ***Describe the process of manufacturing precision gear systems.***

1. Calculate the required dimensions when cutting a spur gear and rack.
2. Describe common methods of manufacturing and finishing gears.
3. Analyze the factors when selecting materials for manufacturing gears.
4. Describe the factors that cause premature gear failure and preventative measures.
5. Describe the inspection methods used to measure the design specifications on gears.

**F. Abrasives (150301f) ..... 3 Hours**

***Outcome:*** ***Select the correct type of cutting tool for abrasive operations.***

1. Explain the types and uses of abrasives.
2. Analyze the various physical and material characteristics of a wheel and relate them to the standard wheel identification system.
3. Select a grinding wheel for specific applications.
4. Explain preparation and safe installation of a grinding wheel.
5. Describe precision and non-precision finishing processes and their applications.

**G. Grinding Machines and Processes (150301g) ..... 6 Hours**

***Outcome:*** ***Explain grinding machines and processes.***

1. Describe surface grinders and their types, parts and holding devices.
2. Explain operations of surface grinders.
3. Describe cylindrical grinders and their types, parts and holding devices.
4. Explain the operations of cylindrical grinders.
5. Describe centerless grinders and their types, parts ad work-supporting devices.
6. Explain operations of centerless grinders.
7. Describe tool and cutter grinders, their types, parts and holding devices.
8. Explain operations of tool and cutter grinders.

**H. Boring Mills (150301h) ..... 4 Hours**

***Outcome:*** ***Describe the types of operations performed on boring mills.***

1. Describe types, parts and controls of horizontal boring mills.
2. Describe accessories, operations, speeds and feeds of horizontal boring mills.
3. Describe types, parts and controls of vertical and planer-type boring mills.
4. Describe accessories, operations, speeds and feeds of vertical and planer-type boring mills

**I. Jig Boring and Grinding (150301i) ..... 2 Hours**

***Outcome:*** ***Explain the operation of jig borers and grinders for accurate hole location.***

1. Differentiate between the purposes and construction of jig borers and jig grinders.
2. Describe tooling and tool holding devices used on jig borers.
3. Describe tooling and tool holding devices used on jig grinders.
4. Describe work holding devices and methods of location of jig borers and jig grinders.

**J. Machine Broaching (150301j) ..... 1 Hour**

***Outcome:*** ***Describe broaches and broaching machines.***

1. Describe the design and application of various broaches.

**K. Jigs and Fixtures (150301k)..... 5 Hours**

***Outcome:*** ***Describe the design and application of jigs and fixtures.***

1. Describe the design principles related to jigs and fixtures.
2. Describe locating and clamping devices used in jigs and fixtures.
3. Describe the applications of jigs and fixtures.

**L. Estimating (150301l)..... 4 Hours**

***Outcome:*** ***Use a machine shop estimating process.***

1. Explain the terms and concepts related to estimating.
2. Determine the cost of materials for a job.
3. Determine the cost of labour for a job.
4. Perform a final cost estimate for a job.

**SECTION TWO:..... COMPUTER NUMERICAL CONTROL MACHINES ..... 25 HOURS**

**A. CNC Turning Centers: Program Codes and Formats (150302a)..... 4 Hours**

***Outcome:*** ***Identify and explain basic CNC concepts, programming codes and applications.***

1. Identify basic CNC concepts and terminology.
2. Identify, explain and apply preparatory (G) codes.
3. Identify, explain and apply miscellaneous (M) and speed (S) codes.
4. Identify, explain and apply tool (T) and feedrate (F) codes.
5. Identify, explain and apply the block-skip function.
6. Identify, and explain the components of typical program formats.
7. Identify and apply a simple CNC program for turning centers and lathes.

**B. Fixed Canned Cycles (150302b)..... 1 Hour**

***Outcome:*** ***Write a CNC program using fixed canned cycles for facing, turning and boring operations.***

1. Identify and apply fixed canned cycles for square and tapered facing operations.
2. Identify and apply fixed canned cycles for cylindrical and tapered turning operations.
3. Identify and apply fixed canned cycles for cylindrical and tapered boring operations.

**C. Linear and Circular Interpolation (150302c) ..... 1 Hour**

***Outcome:*** ***Identify, program and apply linear and circular tool path motions for workpieces having cylindrical diameters, square shoulders, chamfers, tapers, and concave and convex surfaces.***

1. Identify elements of and apply linear tool path motions (linear interpolation) for turning operations.
2. Identify elements of and apply circular tool path motions (circular interpolation) for turning operations.
3. Write a CNC lathe program including linear and circular tool path motions.

**D. Multiple Repetitive Cycles (150302d) ..... 4 Hours**

***Outcome:*** ***Use repetitive machining cycles for turning, boring, facing, radial and face grooving, and drilling operations.***

1. Identify, explain and apply turning and boring repetitive cycles.
2. Identify, explain and apply facing repetitive cycles.
3. Identify, explain and apply pattern repeating repetitive cycles for pre-shaped forgings and castings.
4. Identify, explain and apply repetitive cycles for radial grooving operations.
5. Identify, explain and apply repetitive cycles for face grooving operations.
6. Identify, explain and apply repetitive cycles for drilling operations.

**E. Tool Nose Radius Compensation (150302e) ..... 3 Hours**

***Outcome:*** ***Identify, explain the purpose of and apply tool nose radius compensation (TNRC) for CNC turning, facing and boring operations.***

1. Identify and explain the purpose of TNRC for turning, facing and boring operations.
2. Identify and calculate the TNRC values (offsets) using trigonometric functions.
3. Identify and explain the program codes used in TNRC for turning, facing and boring operations.
4. Locate, identify and explain the machine control requirements for TNRC.
5. Apply TNRC in CNC programs for turning centers and lathes.

**F. CNC Threading: Introduction and Calculations (150302f) ..... 3 Hours**

***Outcome:*** ***Identify thread parts, forms and characteristics, and perform the calculations required for programming threading operations.***

1. Identify and describe common thread nomenclature, terminology and thread forms.
2. Identify and calculate basic data required for threading.
3. Identify and determine the infeed, accumulative infeed and diameter positions for threading.
4. Identify, determine and apply cutting conditions for threading.
5. Identify and discuss the advantages and disadvantages of tool infeed methods for threading.
6. Identify, determine and state applications for acceleration, deceleration and offset distances.

**G. CNC Threading: Programming and Troubleshooting (150302g) ..... 5 Hours**

***Outcome:*** ***Identify and develop CNC threading programs, select tooling and discuss problems and solutions for such operations.***

1. Identify, select and apply single block programming for cylindrical threading operations.
2. Identify, select and apply canned cycles for cylindrical threading operations.
3. Identify, select and apply repetitive cycles for cylindrical threading operations.
4. Identify, select, and apply threading cycles for tapered threading operations.
5. Identify, select and apply programming for multiple start threads.
6. Identify, select and apply programming for tapping operations.
7. Identify and select inserts and tooling for threading operations.
8. Identify common threading problems, causes and solutions.

**H. Tool Measurements (150302h) ..... 2 Hours**

***Outcome:*** ***Identify, explain and apply terms, concepts and tool measuring methods used on CNC turning centers and lathes.***

1. Identify and explain terms and concepts used in tool measurement and offsets.
2. Identify and apply manual tool co-ordinates using G50 program code.
3. Identify and apply tool geometry measurements.
4. Identify and apply tool measurement using a master reference tool and workshift.
5. Identify and apply automatic tool measurements using a qualified tool setter (Q-setter) and workshift.

**I. Machine Control and Operation (150302i) ..... 2 Hours**

***Outcome:*** ***Identify control features and use the functions for machine set-up and operation.***

1. Identify and state the purpose of the major components and features of a typical CNC operator panel.
2. Identify the family of CNC operations and the type of procedures performed within each.
3. Identify and state the purpose of the commonly used screens and files found on CNC turning centers.
4. Identify, select and apply operation procedures for common machine operations.
5. Identify and apply procedures for program input, storage, editing, verification and testing.

**SECTION THREE: ..... TRADE MATHEMATICS ..... 24 HOURS**

**A. Applied Mathematics ..... 2 Hours**

***Outcome:*** ***Perform calculations using applied mathematics.***

1. Demonstrate an ability to read and interpret tables, charts and graphs.

**B. Introduction to Trigonometry ..... 8 Hours**

***Outcome:*** ***Perform calculations using trigonometry.***

1. Identify and define terms related to right triangles and basic trigonometry.
2. Use tables of natural trigonometric functions to find the angles for given values.
3. Be able to properly perform functions to calculate angles for given values with the use of a calculator with trigonometric functions.
4. Be able to correctly solve problems for parts of different triangles.

**C. Shop Applications of Trigonometry - Imperial and Metric ..... 12 Hours**

***Outcome:*** ***Perform calculations using shop application of trigonometry–imperial and metric.***

1. Use trigonometry to solve common machine shop problems.

**D. CNC Math ..... 2 Hours**

***Outcome:*** ***Demonstrate the ability to use CNC math.***

1. Introduction to CNC math.

**SECTION FOUR: ..... PRINT READING ..... 16 HOURS**

**A. Interpret and Sketch Prints (150304a) ..... 6 Hours**

***Outcome:*** ***Interpret and sketch prints using various dimensioning systems.***

1. Describe the application of special dimensioning systems.
2. Describe and identify the characteristics associate with geometric tolerance symbols.

**B. Print Reading: Casting (150304b) ..... 4 Hours**

***Outcome:*** ***Sketch and interpret various information found on a casting print.***

1. Sketch and apply casting criteria to various components.

**C. Print Reading: Jigs and Fixtures (150304c) ..... 6 Hours**

***Outcome:*** ***Describe basic jigs and fixtures.***

1. Sketch and describe common jigs and fixtures.

**SECTION FIVE: ..... MACHINERY'S HANDBOOK ..... 8 HOURS**

**A. Machinery's Handbook ..... 8 Hours**

***Outcome:*** ***Use the Machinery's Handbook to locate and interpret various tables, charts, graphs, text and other relevant information applicable to machine shop operations.***

1. Describe the Machinery's Handbook and explain its advantages.
2. Explain how to find information in the Machinery's Handbook.
3. Explain how to interpret tables, charts and other information found in the Machinery's Handbook.
4. Describe the contents of the Machinery's Handbook as applicable to the second year curriculum.

**SECTION SIX: ..... SHOPWORK ..... 117 HOURS**

Shopwork experience should relate items outlined in the theory section to shop operations by producing selected shop projects. This experience should complement the theory instruction by providing opportunities for efficient, productive and safe operation and/or demonstration of:

**A. Grinding**

***Outcome:*** ***Demonstrate the ability to use and select grinding materials and components for various operations.***

1. Demonstrate an ability to select proper grinding wheels for common grinding operations.
2. Properly perform truing and dressing operations on various types of grinding wheels.
3. Demonstrate an ability to properly mount and balance various grinding wheels.
4. Demonstrate an ability to perform various operations on common grinders.

**B. Milling**

***Outcome:*** ***Demonstrate an ability to perform indexing operations for milling machine set-ups.***

1. Demonstrate an ability to perform indexing operations for milling machine set-ups.
2. Demonstrate an ability in setting up a dividing head and milling machine for common operations.
3. Demonstrate an ability to utilise the milling machine to perform common operations.
4. Perform various gear tooth measurements utilising common methods available.

**C. Lathe Work – Threading**

***Outcome:*** ***Perform lathe work, threading, set-up and thread cutting operations.***

1. Demonstrate an ability to set-up and perform thread cutting on the engine lathe.

**D. Boring Mills**

***Outcome:*** ***Perform boring mill, set-up and operation.***

1. Demonstrate an ability to set-up and perform boring operations on the horizontal boring mill.

**E. Machine Broaching**

***Outcome:*** ***Perform machine broaching and set-ups.***

1. Demonstrate the ability to set-up and perform broaching operations on a broaching machine.

**F. Jigs and Fixtures**

***Outcome:*** ***Demonstrate various applications of jigs and fixtures.***

1. Demonstrate the proper use and application of various common jigs and fixtures.

**G. Computer Numerical Control Machining**

***Outcome:*** ***Perform CNC programming by designing and executing a simple program on a CNC lathe.***

1. Demonstrate an ability to design and execute a simple program on a computer numerical control lathe.

**FOURTH PERIOD TECHNICAL TRAINING**
**MACHINIST TRADE**
**COURSE OUTLINE**

*UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.*

**SECTION ONE:..... THEORY ..... 68 HOURS**

**A. Spur Gears and Milling (150401a) ..... 2 Hours**

***Outcome:*** ***Describe indexing and spur gears.***

1. State four methods of indexing by completing assigned exercises.
2. Spur gear elements and calculations.

**B. Helical Gears (150401b) ..... 4 Hours**

***Outcome:*** ***Identify parts of helical gears, applications for helical gears, methods of manufacturing helical gears, and an understanding of the processes used for set-up.***

1. Identify the main elements of helical gears.
2. Identify applications for helical gears, as well as their advantages and disadvantages.
3. Describe the methods used to manufacture helical gears.
4. Understand the basic set-up for helical milling of helical gears.

**C. Worm Gears (150401c) ..... 4 Hours**

***Outcome:*** ***Describe the various methods for producing worm gears.***

1. Describe worm gear systems, uses, applications and manufacturing.
2. Describe methods of manufacturing worm gears.
3. Describe the elements and perform calculations to manufacture worm gears.

**D. Bevel Gears (150401d) ..... 2 Hours**

***Outcome:*** ***Describe the applications and elements of bevel gears.***

1. Describe the types and applications of bevel gears.
2. Describe the main elements of bevel gears.

**E. Cams (150401e) ..... 2 Hours**

***Outcome:*** ***Describe common cams and their applications.***

1. Describe the classes and types of cams and their applications.

**F. Graduating (150401f) ..... 2 Hours**

***Outcome:*** ***Explain linear graduating on a milling machine.***

1. Explain the process for linear graduating on a milling machine.

**G. Splines (150401g) ..... 4 Hours**

***Outcome:*** ***Describe the various methods for producing splines.***

1. Describe types of splines and their applications.
2. Describe methods of manufacturing splines.
3. Describe calculation methods of manufacturing splines.

**H. Bearings and Seals (150401h) ..... 5 Hours**

***Outcome:*** ***Explain how to choose and install bearings and seals.***

1. Describe the types and applications of plain bearings.
2. Describe the types and applications of roller bearings
3. Explain bearing installation procedures.
4. Describe types and applications of seals.

**I. Belts and Pulleys (150401i) ..... 3 Hours**

***Outcome:*** ***Explain how to choose and install belts and pulleys.***

1. Describe the types and applications of belts and pulleys.
2. Describe methods of belt and pulley sizing.
3. Explain pulley and belt installation and maintenance procedures.

**J. Basic Hydraulics (150401j) ..... 4 Hours**

***Outcome:*** ***Describe simple hydraulic systems as applied to machine tools.***

1. Identify the basic components of simple hydraulic systems.
2. Describe the application of simple hydraulic systems to various machine components.

**K. Non-Traditional Manufacturing Processes (150401k) ..... 12 Hours**

***Outcome:*** ***Describe non-traditional process used in manufacturing.***

1. Describe the processes and applications of electromechanical machining to remove metal.
2. Describe the use of thermal processes for machining metal.
3. Describe the process and applications of powder metallurgy for the mass production of parts.
4. Explain the use of static and dynamic balancing to reduce vibration in rotating equipment.
5. Describe three methods of deep-hole drilling and their applications.
6. Describe new technological advancements that are relevant to manufacturing processes.

**L. Introduction to Limits and Fits (150401l) ..... 6 Hours**

***Outcome:*** ***Explain how to ensure interchangeability between machined parts through the application of standards of limits, fits and quality control programs.***

1. Define the terminology related to standards of limits and fits.
2. Explain the application of standards of limits and fits to machined parts.
3. Explain the application of quality control procedures to modern manufacturing.

**M. Surface Finish (150401m) ..... 6 Hours**

***Outcome:*** ***Explain concepts related to surface finish.***

1. Define terms related to the production and measurement of surface finishes.
2. Identify common surface finish symbols used to indicate surface finish values.
3. Choose an appropriate machining or finishing process to produce a given surface finish.

**N. Precision Measurement (150401n) ..... 6 Hours**

***Outcome:*** ***Explain the use of precision measuring tools and systems for direct measurement.***

1. Explain how to use a sine bar or a sine plate to measure an angle.
2. Explain how to use precision measuring systems to measure size, flatness and surface finish.
3. Explain how a co-ordinate measuring machine (CMM) is used to accurately measure machined components.

**O. Gauges and Comparators (150401o) ..... 2 Hours**

***Outcome:*** ***Explain the use of inspection gauges and comparators for indirect measurement.***

1. Explain the use of inspection gauges.
2. Explain five methods of comparison measurement.

**P. Calibration of Measuring Tools (150401p) ..... 4 Hours**

***Outcome:*** ***Describe methods of checking and calibrating precision measuring tools.***

1. Describe a system for determining the accuracy of micrometers and dial indicators using gauge blocks.
2. Explain the ways of determining whether a gauge is within tolerances laid out for gauges.

**Q. Working and Coaching Skills ..... 0 Hours**

1. Describe and demonstrate the coaching skills used for training apprentices.

**R. Advisory Network ..... 0 Hours**

1. Explain the role and purpose of the advisory network and the Provincial Apprenticeship Committee for the Machinist trade.

**SECTION TWO: ..... COMPUTER NUMERICAL CONTROL MACHINES ..... 44 HOURS**

**A. Machine Types, Parts and Functions (150402a) ..... 4 Hours**

***Outcome:*** ***Identify and explain the purpose of CNC machining centers, milling machines, their parts and functions.***

1. Identify the types of CNC machining centers and milling machines with appropriate application.
2. Identify and describe the parts, functions and features of CNC machining center.
3. Identify the elements of a CNC drive system and probes.
4. Identify and describe workholding devices and accessories used on CNC machining centers.
5. Identify and discuss safety practices when using CNC machines.

**B. Manufacturing Systems (150402b) ..... 3 Hours**

***Outcome:*** ***Identify and explain the manufacturing systems that evolved through advances in computer technology used in machining industry.***

1. Identify and explain the flexible manufacturing system (FMS).
2. Identify and explain the computer integrated manufacturing (CIM) system.

**C. Machine and Workpiece Co-ordinate Systems (150402c) ..... 4 Hours**

***Outcome:*** ***Identify, determine and explain the purpose of co-ordinate systems, machine axis, workpiece co-ordinates and reference points used on CNC machining centers and milling machines.***

1. Identify, determine and apply co-ordinate systems and dimensions for programming.
2. Identify and explain the purpose of the machine axis system.
3. Identify and state a purpose for reference points and work co-ordinate system.
4. Identify and determine co-ordinate points for simple workpieces.

**D. Programming Concepts, Codes and Structure (150402d) ..... 6 Hours**

***Outcome:*** ***Identify and explain CNC concepts, programming codes and applications.***

1. Identify CNC program concepts and terminology.
2. Identify, explain and apply preparatory (G) codes.
3. Identify, explain and apply miscellaneous (M) and speed (S) codes.
4. Identify, explain and apply tool (T) and feedrate (f) codes.
5. Identify, explain and apply block-skip program functions.
6. Identify, explain and apply workpiece shift and tool length offset program codes.
7. Identify components of a CNC program for machining centers and milling machines.

**E. Machining Conditions (150402e) ..... 4 Hours**

***Outcome:*** ***Identify, select and apply speeds, feed rates and depth of cuts for common machining operations performed on machining centers and milling machines.***

1. Determine, select and apply cutting speeds for machining operations performed on machining centers.
2. Select, determine and apply feedrates for machining operations performed on machining centers.
3. Select, determine and apply depth of cut for milling operations.
4. Identify and state the purpose of common operations performed on machining centers and milling machines.

**F. Canned Cycles: Theory (150402f) ..... 3 Hours**

***Outcome:*** ***Identify and explain the canned cycles used for drilling, boring and tapping operations performed on CNC machining centers and milling machines.***

1. Identify and explain the program variables used in canned cycles.
2. Identify, explain and apply drilling canned cycles.
3. Identify, explain and apply the tapping canned cycle.
4. Identify, explain and apply boring canned cycles.

**G. Canned Cycles: Program Applications (150402g) ..... 3 Hours**

***Outcome:*** ***Identify and prepare canned cycle programs for drilling type operations for CNC machining centers and milling machines.***

1. Identify and calculate co-ordinate points for typical hole patterns.
2. Identify and calculate depth of holes for drilling operations.
3. Identify and apply canned cycles for drilling type operations including tapping and boring.
4. Identify and apply canned cycles with repeat (L) function for linear and grid hole patterns.
5. Identify and apply canned cycles using polar co-ordinates.

**H. Linear and Circular Interpolation (150402h) ..... 4 Hours**

***Outcome:*** ***Identify, program and apply linear and circular interpolation for profile milling operations.***

1. Identify elements of and apply linear tool path motions (linear interpolation) for milling operations.
2. Identify elements of circular interpolation for milling operations.
3. Identify, explain, calculate and apply arc modifiers for circular interpolation.
4. Write a CNC program including linear and circular tool path motions for machining centers and milling machines.

**I. Cutter Radius Compensation (150402i) ..... 4 Hours**

***Outcome:*** ***Identify, explain the purpose of, and apply cutter radius compensation (CRC) for machining workpiece profiles on CNC machining centers and milling machines.***

1. Identify and calculate the co-ordinates for cutter center path programming.
2. Identify and explain the program codes, machine setting and guidelines for cutter radius compensation (CRC).
3. Identify and state the advantages of CRC.
4. Identify and apply CRC for profile milling operations.

**J. Advanced Programming Concepts and Application (150402j) ..... 5 Hours**

***Outcome:*** ***Identify and explain the purpose of CNC machining centers, milling machines, their parts and functions.***

1. Identify, select and apply subprograms for appropriate machining applications.
2. Identify and state an application for macro programs.
3. Identify, select and apply mirror image for appropriate machining applications.
4. Identify, select and apply co-ordinate rotation for appropriate machining applications.
5. Identify, select and apply helical milling for thread milling operations.
6. Identify, select and apply part zero shift programming techniques.

**K. Set-Up and Operations (150402k) ..... 4 Hours**

***Outcome:*** ***Perform machining operations on CNC milling machines and machining centers.***

1. Identify and perform tool-loading operations into tool magazines.
2. Identify the sequence of operations for sequential (direct) tool change operation.
3. Identify the sequence of operations for a swing-arm tool change operation.
4. Identify and perform tool length and tool length offset measurements.
5. Identify and perform workpiece co-ordinate or workshift measurements.
6. Identify and state the purpose of common features found on the operator's panel of a machining center.

**SECTION THREE: .....MACHINERY'S HANDBOOK..... 8 HOURS**

**A. Machinery's Handbook..... .....4 Hours**

***Outcome:*** ***Demonstrate ability in the use of the machinery handbook.***

1. Locate and interpret various table, charts, graphs and other pertinent information applicable to common machine shop requirements.

**B. Trade Math.....4 Hours**

***Outcome:*** ***Solve problems by using trade math for machine operations.***

1. Solve problems related to machine operations in the trade.

**SECTION FOUR: .....SHOPWORK..... 128 HOURS**

Shopwork experience should relate items outlined in the theory section to shop operations by producing selected shop projects. This experience should complement the theory instruction by providing opportunities for efficient, productive and safe operation and/or demonstration of the following:

**A. Milling .....**

***Outcome:*** ***Perform various milling operations using indexing methods.***

1. Demonstrate an ability to set-up and perform milling operations using various indexing methods.

**B. Special Machines and Processes**

***Outcome:*** ***Perform special machine and process operations.***

1. Demonstration or perform operations using special machines and/or processes.

**C. Computer Numerical Controlled (CNC) Machines**

***Outcome:*** ***Perform CNC machine operation by designing and executing a simple program on a CNC center and turning center.***

1. Demonstrate an ability to design, enter and execute a simple program on a computer numerically controlled machining center and turning center.

*Excellence through training and experience*

# 1505

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